feeders, and the chapter is finished with a few words on weighing and sampling.

There is a great deal of varied information contained in the book, but it would have been better to confine the subject to one or other of the branches referred to in the opening paragraph.

DUSTLESS ROADS.

Dustless Roads. Tar Macadam: A Practical Treatise for Engineers, Surveyors, and Others. By T. Walker Smith. Pp. xi+225. (London: Charles Griffin and Co., Ltd., 1909.) Price 10*s*. 6*d*. net.

THE growing use of motor-cars, and the destructive action due to the rapid speed at which they are driven, and the sucking action of the indiarubber tyres on the surface of the roads, has rendered a change in their management necessary.

It is the almost unanimous opinion of road experts that, in order to preserve the surface of the roads in good condition, it is necessary that some kind of bituminous material must be used for binding the stones of the macadamising, which, while cementing them together, will also give a waterproof and comparatively dustless surface.

The book under notice has, therefore, been published at an opportune time, as the method of repairing roads described in it, which has been more or less successful, has been so far only of a tentative character, the work not being carried out on any scientific basis, but very much by the rule of thumb.

The author, who was borough engineer at Barrow-in-Furness for several years, had under his charge many miles of macadamised roads subject to motor traffic, and devoted his attention to experimenting and trying to find out the best means of solving the difficult problem of keeping these roads in good order, and preventing the creation and spreading of dust, at a reasonable outlay. The results of his experience are given in the book under notice. The author, however, not content with his own experience, has also collected the opinions of a large number of road surveyors throughout the country as to the advantages and disadvantages, and cost of tar macadam, the answers to the queries submitted being given in the tables contained in the book.

The subjects dealt with are divided into fifteen chapters relating to tar macadam as a remedy for dust nuisance; the necessity for standardisation in construction; tar; aggregates for tar macadam; preparation and laying; mechanical mixing; effect of wear and tear; scavenging, watering, and maintenance; camber, gradient, noiselessness, and hygienic advantages; tractive effort; statistics of road mileage; cost of maintenance; and tar spraying. There are twenty-four illustrations and a tabulated analysis of the replies to queries.

The author shows that the binding material used in the making or repair of macadamised roads is the crux of efficient road maintenance and the prevention of dust. His opinion is that it is absolutely necessary, if macadamised roads are to meet the needs of present-day traffic with the searching demands that motor traffic makes on the surface of the road, that a bituminous binding or matrix should be employed. He points out that so far, although this fact is fully recognised, no scientific study has been made to standardise the materials used, and the proportion and quality of this material:—

> "Thus the matrix is usually prepared as it seems best to the individual in charge of the tar boiler who uses anything that comes from the local gas works; who boils it as long as he thinks necessary, and adds to it whatever he thinks may improve it in the way of pitch or creosote. It is a subject in which the personal factor has entered to an exceedingly great extent, and each man acts more or less as it seems best to him in his own mind."

The aggregates for tar macadam are also fully dealt with. The author points out that as the tar binding cements the stones together, the abrasion caused by friction in water-bound macadam is thus absent, the properties of noiselessness, elasticity, and resilience being secured. The only portion of the road material which is subject to any considerable wear is the surface, which has to bear the friction due to the rolling of the wheels, and also the impact of the horses' feet. It is, therefore, contended that the use of granite or other similar expensive material is not necessary for the lower coat, which consists of from 80 to 85 per cent. of the whole; but that where the road is only subject to moderate traffic the lower layer may consist of hard limestone or slag, either of which material holds the tar better than granite; the upper layer, which has to bear the surface wear and tear, being composed of granite. The author's experience leads him to the conclusion—

> "that it is an absolute waste of money to put such good material as granite in the bottom when a less costly material will do perfectly well when armoured with a good coating of tarred granite."

The patent processes known as "Tarmac" is described. The makers of this road material have expended upwards of 20,000*l*. in the construction of works and plants at Wolverhampton. The aggregate used is slag, the tar is distilled before using, and the mixing is done by machinery. The author, however, does not seem to think that it has any special advantage over ordinary tar macadam mixed locally when this is done in a proper manner. In the tables the cost of the materials and of mixing and laying is given for a great number of localities. As an average this may be taken as from two shillings to half a crown per square yard for a coating of 3½ inches of slag and hard limestone for the bottom layer, and half an inch of tarred granite for the surface coat. The general opinion appears to be that there is a saving in the cost of maintenance of roads where tar macadam is used in place of water-bound macadam, in some cases amounting to as much as 75 per cent., the average, however, being put at 37½ per cent.

With occasional tarring and sanding of the surface, a tar-macadam road, so far as the lower layer is concerned, is practically everlasting. The surface

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where there is much traffic requires re-covering about once in four years. Instances are given from the author's own experience where roads having a fair amount of traffic "have been as good at the end of six years as when first covered, and so far as can be seen will need very little for another six years."

This book ought to be carefully studied by all surveyors having charge of roads subject to motor traffic.

VECTORIAL GRAPHICS.

Vectors and Vector Diagrams applied to the Alternating Current Circuit. By W. Cramp and C. F. Smith. Pp. xvi+252. (London: Longmans, Green and Co., 1909.) Price 7*s.* 6*d.* net.

NOT many years ago a certain type of journalist used to compare and contrast the theorist and the practical man, to the demolition of the former and the apotheosis of the latter. Fortunately, such an attitude of mind is no longer possible. The merely practical man could never have constructed the Forth Bridge, nor launched the *Mauritania* on her record-making career. Innumerable examples might be given of the necessity of true theory in the economical designing of all kinds of machinery; but probably there is nothing that better proves how much mathematical science lies at the foundation of modern methods than electrical applications, especially those that have to do with the alternating current. The whole history of the development of the transformer and the alternating-current motor is simply the realisation of the solution of a differential equation given long ago by Maxwell. In this realisation the first great steps were taken by Heaviside, who introduced the terms impedance, admittance, reluctance, &c., giving a new precision to the ideas involved. By a mathematical extension of meaning the symbols which entered into the electrical equations of steady currents became applicable to the corresponding cases of sinusoidal currents. Stated in purely mathematical language, this transition depended on the properties of the complex variable.

Thus, to take the simplest case, Ohm's law $RC=E$ for steady electromotive force becomes Maxwell's expression $(R+L d/dt)C=E$ when E is variable. Representing a sinusoidal electromotive by the exponential of the imaginary ipt, we get the solution in the form $(R+iLp)C=E$, where C and E now stand for the amplitudes of the varying quantities. This complex quantity which operates on C may be treated analytically like the real quantity R in Ohm's law. Multiplication by the conjugate gives

$$(R^2+L^2p^2)C=(R-iLp)E.$$

In the end, after all analytical transformations have been effected, the real part of the expression must be picked out. A little experience will make the average student quite efficient in this kind of algebra, especially if it is combined with numerical and practical work.

But the value of the method does not stop here. Following familiar paths, we may give a geometrical form to the expressions, and obtain graphical representations of important relations. Thus the complex quantity $RC+iLpC$ may be laid down as a vector in a plane, RC being the component along a chosen direction and LpC the component at right angles to this direction, while the ratio Lp/R measures the tangent of the angle between the vector and the chosen direction of reference. Again, if we regard C as a complete vector, the complex operator may be considered to be a versor rotating C through the angle just named. Can we utilise these fundamental vectorial and versorial conceptions to construct a graphical representation of real value to the electrical engineer? The answer has been given in the affirmative; and among those who have worked up the method along these lines, no one holds a higher place than C. P. Steinmetz. The method has been presented in more or less detail in most of the recent books on the alternating current, and now we have an extremely valuable addition to the literature of the subject in "Vectors and Vector Diagrams applied to the Alternating Current Circuit," the joint work of William Cramp and Charles F. Smith, both lecturers in the electrical engineering school of Manchester University. The authors, for reasons given, depart somewhat from Steinmetz in their development of the method, but the foundation is essentially the same. Once the fundamental propositions are admitted and grasped, the whole treatment is a model of lucidity and self-consistency. One unusual feature of the book is that it assumes a certain fairly advanced knowledge at the start. This is a good feature, which might well characterise more of our text-books. The authors are careful at the same time to indicate exactly what knowledge the student must possess before he is in a position to make effective use of their methods—he must know the fundamental laws of the alternating-current circuit very thoroughly. Nevertheless, it would have been of advantage to have indicated in a few preliminary sections the manner in which the method originally took shape as a synthesis of the symbolic solutions of Maxwell's differential equations. There also seems to be a certain looseness of argument in the way in which the properties of vectors are stated. For example, having defined in the usual geometrical way the meaning of the "vector product" of two vectors, and having so named it, they remark, "This product must itself be a vector product, since it has already been shown to possess a definite sense." This is no proof, but mere statement. The defined product must be shown to obey the vector law of addition before it can be called a vector product.

These imperfections do not, however, affect the purpose of the authors, who are to be congratulated on having enriched our technical literature with a clear and systematic exposition of the vectorial graphics of alternating-current phenomena. After a discussion of the more purely geometrical character of the method, illustrated throughout by reference to familiar electrical phenomena, a succession of chapters follows on self and mutual induction, the transformer, motors of the induction type, and alternating-current commutator motors. A chapter is then thrown in on the product of two vectors, and the two concluding and longest chapters deal respectively with locus

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